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TRANSACTIONS
of
THE NEW YORK ACADEMY OF SCIENCES

Ser. II, Vol. 3 DECEMBER, 1940 No. 2

SECTION OF GEOLOGY AND MINERALOGY

NOVEMBER 4, 1940

DOCTOR MAX DEMOREST, Department of Geological Sciences, Yale University; *The Rock Called Ice.* (This lecture was illustrated by lantern slides.)

The petrologist has long recognized that ice is a rock, but having made that recognition he has done little to make an acquaintance. Among geologists, therefore, the task of studying this rock has fallen to the geomorphologist; and this is to be expected, for most of the natural occurrences of ice are at the earth's surface where they are geologically important as factors in the erosional and depositional history of many land forms. He studies the igneous rock called ice when he finds it in winter on the surfaces of our ponds and lakes. There he is interested in the pressure of expanding ice and the shoreline ramparts it builds. He studies the sedimentary rock called ice when he finds it in the perennial snows of high altitudes and high latitudes. There he is interested in nivation effects and the peculiar erosional processes that are associated with such snows. Of even more interest are the larger areas of snow—the névé fields which are the feeding grounds of glaciers; while in the glaciers themselves he finds the metamorphic rock called ice, for the sedimentary snow and firn

TRANSACTIONS of The New York Academy of Sciences, Series II, Volume 3, No. 2, December, 1940.

This publication is distributed to Members and is published monthly from November to June, inclusive, at 8–10 W. King Street, Lancaster, Pa., by The New York Academy of Sciences, Seventy-ninth Street and Central Park West, New York City.

Associate Editor: Eunice Thomas Miner, Executive Secretary.

Entered as second-class matter December 2, 1938, at the post office at Lancaster, Pa., under the act of August 24, 1912.

of the névé is very truly metamorphosed in the process of flowage which causes a continuous movement of ice from the head toward the snout of a glacier.

In studying this latter subject—the flowage and metamorphism of ice—the geomorphologist finds himself in the fields of structural petrology and applied physics; and he finds himself in need of techniques that he has hitherto neglected. The petrologist in working on the metamorphism of other rocks has made constant use of the petrographic microscope and, within the last two decades, has developed the technique of petrofabric analysis wherein a universal stage is used to make statistical studies of crystallographic and dimensional orientations of mineral grains in rocks. An attempt is made to relate these orientations to the forces thought to be responsible for the deformation and metamorphism of the rock. More recently, the petrologists have conducted experimental studies with a view toward the laboratory production of rock flowage under controlled conditions of temperature, static pressure, and deformational stress.

Thanks to Yale University, the National Research Council, the Geological Society of America, and the Society of Sigma Xi, I have been privileged to pioneer in the application of these techniques to the study of ice deformation. However, the fact that ice is a rock of rather peculiar properties has demanded that the techniques be modified in some respects. The most obvious peculiarity of this rock is its low melting point, a fact that makes it necessary to conduct all studies and experiments at a temperature below 32° F. While this makes no fundamental difference in the methods used, it does work a hardship on the fingers of the student and makes long woollen underwear a scientific necessity. Another peculiarity of ice is the large grain size which characterizes it in many of its forms. Igneous ice on lakes may contain individual grains of several inches across, and the metamorphic ice of a glacier is frequently made up of grains measuring up to six inches. For the study of such large grained material it is obvious that the ordinary microscope and universal stage of the petrographer is much too small, so it has been necessary to con-

Pub.
New York Academy of Sciences
1-6-1941

struct special apparatus. The universal stage now in use has a diameter of fourteen inches and will take thin sections measuring half that distance across. Seven inch discs of polaroid are used as polarizer and analyser.

Fortunately, the birefringence of ice is so low (0.004) that sections need not be ground as thin as for other rocks. Twenty to thirty thousandths of an inch is usually sufficient, and, since ice is a soft material, sections can be ground rapidly. The method of making sections is essentially the same as that used by petrographers, but a common hand saw takes the place of the expensive rock saw. Coarse grinding is done with a rotary wire brush attached to an electric motor and the finishing is done on emery cloth laid flat on a smooth board. Instead of balsam cement, a little water is applied around the edges of the specimen with an eye dropper. No cover glass is used since the sections, being relatively thick, are not fragile, and it is not practical to preserve them for any great length of time. Yet, in the subfreezing laboratory, they can be conveniently stored for many months in kerosene where evaporation is prohibited.

Thus far, the petrologic studies of ice which I have conducted have been of two sorts:—first, laboratory experiments on the deformation of ice; and second, field studies of deformed ice in glaciers. In the experimental work, small cylinders of ice are cut from large single crystals found in clear lake ice. Each cylinder is mounted in a chamber where controlled high static pressures may be applied and the temperature regulated to any desired value. Then deformational pressures are applied which force the ice to flow by slowly squashing it. By separately varying the pressure, temperature, and deformational stress over a large series of tests the effect of each of these factors on the flow of ice may be evaluated. Thin section studies of cylinders removed from the apparatus after different degrees of deformation reveal the nature of the crystallographic changes which develop as flow progresses. To fully study the subject by this method, hundreds of specimens should be tested—a task requiring several years. As yet, only preliminary studies are under way, so no definitive results have been obtained.

The field work has been done at Mt. Rainier where numerous glaciers supply an abundance of material, and where the National Park Company kindly put a cold storage room at our disposal. Samples of ice were collected from glaciers at localities where visible structures seemed to show the probable distribution of deforming stresses. Back in the cold room, these samples were cut in thin section and petrographic studies made. As with the laboratory work, there is more to do in the future than has yet been done. Nevertheless, interesting results have been obtained. Most important of these results is a demonstration that ice flowage proceeds by a process of recrystallization. In this process, the small, approximately equidimensional grains of the névé are transformed into large, irregular, interlocking grains that fit together like pieces of a three dimensional jig-saw puzzle, and the flowage of ice results from a continuous adjustment of grain forms to accommodate the stresses. While recrystallization has previously been suggested as the principal process of glacier flow, the exact nature and method of that recrystallization have not been understood hitherto; nor have the present studies brought certainty to our understanding, though we have formed tentative conclusions which seem to offer a satisfactory explanation.

While these conclusions were orally discussed in the lecture, a published discussion of them now would be premature. This is especially so, since experimental tests are in preparation which will allow us to see and photograph thin sections of ice under high confining and shear stresses. The ice will be forced to flow, while, by means of polarized light, we watch and take moving pictures of the progression of crystallographic changes. If we should see what I think we shall see, we shall know that our tentative conclusions are right. If we see something else, we shall know either that our conclusions are wrong, or that the apparatus does not produce flow conditions similar to those in a glacier, and that therefore the experimental flow is of a different sort. Perhaps we shall find that both the flow conditions are different and the conclusions wrong. In any case, published discussion should await these experimental tests.

SECTION OF BIOLOGY

November 12, 1940

DOCTOR DUGALD BROWN, New York University and Bellevue Hospital Medical College: *Biological Reactions to High Pressure.* (This lecture was illustrated by lantern slides.) No abstract has been received by the Editor.

SECTION OF PSYCHOLOGY

November 18, 1940

PROFESSOR ROBERT S. WOODWORTH, Columbia University: *Recent Results on Heredity and Environment.*

The pioneer student of twins, as to the light their resemblances and differences throw on the effects of heredity and environment, was Sir Francis Galton. Of recent years, with the development of reliable methods of distinguishing monozygotic or "identical" twins from dizygotic or "fraternal" twins, this line of investigation has received new impetus. Identicals, formed by the splitting of a single individual very early in embryonic life, have the same genes, the same heredity, while fraternals differ in heredity by a variable amount, just as other siblings do. The "twin method," developed in Germany and much used there during the past two decades, proceeds as follows: Find the average difference between identicals in a certain trait. This difference is due to environment, since identicals are alike in heredity. Find the average difference between fraternals also. This difference is due to both heredity and environment, and is practically always greater than the difference between identicals. Now, subtract the difference between identicals (due to environment alone) from the difference between fraternals (due to both heredity and environment), and the remainder is an index of the importance of heredity in making individuals different in the given trait. An assumption underlying the use of this formula is that the environment is as much alike for a pair of fraternals as for a pair of identicals. This assumption is probably justified in respect to the bodily traits, where the twin method has mostly been employed. But when the German psychologists began to use the method for the study of intellectual and character traits, they soon became aware that the assumption was rather dubious. Inquiry in this country (by P. T. Wilson) has shown that identicals are together much more than fraternals, have the same chums, play the same games,

and in other respects have a more common environment than fraternals. So this twin method cannot be used with much precision for psychological investigations. The question remains, and will be alluded to later, as to *why* the environment should differ more for fraternals than for identicals. Meanwhile, the German psychologists, by a more or less cautious use of the method, have made it probable that character differences depend on heredity as well as on environment.

For a time, twin research was very active in the USSR, and the Russian psychologists were using a form of the "co-twin control" method, somewhat like that of Gesell. Take a pair of identicals, and subject one twin to a certain environmental factor, i. e., one kind of training, the other twin to an alternative factor, and see which twin comes along better. Do this, of course, with a considerable number of identical pairs. Some good results were being obtained by this method, when a halt was called by the political authorities. The method seems quite suitable for testing out the effect of environmental factors; and it must be admitted that we now know very little regarding the influence of different environments upon intelligence and personality.

In this country, an outstanding twin study has sought to find twins who have been reared apart since infancy. The method here is another form of co-twin control. Newman, Freeman and Holzinger (1937) were able to find 19 pairs of identicals reared apart, usually in not very diverse environments, but, in a few cases, receiving very different educational advantages. One young woman who had been through college showed an IQ of 116, while her twin who had had only the first two grades in school got 92. This difference of 24 points was the largest found, but there were three other cases in which the twins had received very unequal educational advantages and in which there were corresponding IQ differences measuring 19, 17, and 12 points. In the remaining cases, the twins had been reared under conditions differing about as they differ in the homes of an ordinary community, and we might expect the twins of a pair to differ about as much as two children taken at random from such a community. Actu-

ally, they differed on the average by about 5.5 points, almost exactly as much as found by these authors in a sample of 50 pairs of identical twins brought up together. In fact this is about the same difference as is found on the average between test and prompt retest of the same individual. Taking pairs of unrelated children from the community, we should find them to differ on the average by much more—about 15–18 points. Though the sample of identicals reared apart is still pretty small, two tentative conclusions seem to be justified. First, a large difference in educational environment can produce quite an appreciable difference in tested intelligence. Second, the differences in intelligence found in an ordinary community are not accounted for to any great extent by differences in home and school environment; for, if they were, children having identical heredity, but brought up in different homes, should differ as much as children paired at random from the community.

Broadening the statement somewhat, we are probably justified in saying that differences in intelligence, as we find them in members of the same family or ordinary community, are due in large measure to differences in native capacity, but that, nevertheless, raising the level of the environment (if we knew how to do it) would improve the intelligence of the population in general. These two statements are not contradictory in the least. When the environment is fairly uniform, the differences present in the population must be due mostly to heredity, as Shuttleworth has said (1935). The same author has made another point which deserves emphasis. Heredity and environment interact. Parents giving their children the better heredity will on the whole give them the better environment. Within the same family, we may add, children differing by nature are sure to be treated differently, and they are sure to select differently from among the varied opportunities offered by the environment. Here, we see the reason, probably, why the effective environment differs more for fraternal than for identical twins. Unlike heredity is the primary factor, but unlike heredity operates largely by producing differences in the effective environment.

Another important twin study is that of Rosanoff, Handy & Plesset (1937). Starting from a large sample of mentally deficient individuals who were known to have twins, brothers or sisters, they located those twins and determined their mental level and condition. What per cent of them were normal? In the case of identicals, only 9 per cent; with same-sex fraternals, 39 per cent; with opposite-sex fraternals, 53 per cent; as against 84 per cent of the siblings of mentally deficient individuals. Analysis of these per cents and of other evidence leads the authors to place strong emphasis on prenatal and natal conditions as factors in the causation of mental deficiency. Twins—one or both of a pair—are especially exposed to prenatal malnutrition and birth injury. When one twin of a pair of identicals is normal and the other feebleminded, the normal one proves that the other has the genes for normality. The feebleminded one, for some reason, has not come up to his hereditary potentiality, and the reason is often found in birth injury or prenatal maldevelopment. Rosanoff and his associates believe that minor degrees of brain injury often occur without being noticed at birth. In this way they would explain the occasional cases of identical twins who differ considerably in ability, in spite of having been reared together. They found several such cases among superior children even. One twin in a certain pair of identicals had an IQ of 150, proving that his twin had the genes to reach the same level; but the other's IQ was only 118, which, even though rather high, showed what these authors call "relative mental deficiency," i. e., failure to develop his full hereditary potentiality. Those who use twins for the study of educational and social environment need to be on their guard against disturbance by such physical factors as these authors have stressed.

Besides the twin studies, another main line of investigation consists in removing children from one environment to another, and observing and measuring, so far as possible, the resulting changes in their ability and personality. Of many studies of this type—studies of foster children and of the effect of superior schools and nursery schools—, those recently reported from the

State University of Iowa have attracted most attention, because of the strong claims made for environmental effects. The long-established and excellent nursery school conducted by the University reports an average gain of at least 10 points in IQ resulting from attendance, and the gain in some individual children has been much greater than this. As far as the average is concerned, this result has not been confirmed by several other excellent nursery schools. The Iowa school may be better, or the home environments may be better in the other places, for the child does not come to the nursery school from a vacuum. We may hope that the Iowa school is better and that it well be possible to analyze out the points of superiority, and so discover what sort of early environment is best for intellectual and personality development. As to the individual children who made such large gains, what we need is careful case studies rather than simply a notation of the child's IQ at different ages. If emphasis is to be placed on the individual case, we should know the child's parentage and home environment, and the nature of his improvement in school.

An orphanage, so it would seem, makes a favorable situation for a nursery school experiment, because the usual orphanage environment is not intellectually stimulating to the children. The Iowa psychologists set up a nursery school in such an orphanage, but encountered one serious difficulty. The more promising children were constantly being placed for adoption, so that it was impossible to apply the nursery school environment for a two or three year period to any large group of children. The results, accordingly, were not very clear, though they did seem to show some gain for the nursery school children.

Foster children, also, are being studied by the Iowa group, and they find, as others have found in other States, that foster children turn out encouragingly well. Placement officers, it should be understood, are under moral and legal obligation not to place for adoption any children who are especially poor risks because of parentage, behavior, mental retardation, or medical condition. This restriction makes it difficult to conduct a con-

clusive experiment. But the evidence points to some gain in IQ when children are transferred from poor homes or from the orphanage to good foster homes. At last testing, the children in the Iowa sample were still under five years old on the average, and, as they are being followed up, it is best to delay conclusions. This caution applies to the particular sub-sample of 16 children of feebleminded mothers (average IQ of mothers, about 70; average schooling, 7.6 grades; average schooling of fathers, 9 grades). These children were placed for adoption, in spite of the restrictions above mentioned. After adoption, none of these children turned out to be feebleminded, their average IQ being 116 when they were two years old, and 108 when they were four. This result does not warrant the general statement that children of feebleminded mothers are perfectly safe for adoption. The sample was small and obviously selected (by the placement officials) and the nature of the mother's deficiency is not stated. If a mother is defective because of birth injury, there is no reason to expect her child to be defective. With our increasing knowledge of varieties of feeblemindedness, it is necessary to draw distinctions that were not considered formerly.

There are several other studies of the Iowa psychologists which should be included in a complete survey. In general, this group is to be commended for formulating bold and definite hypotheses, but it is only fair to say that their claims still have the status of hypotheses. The time is not ripe for reaching agreement on the nature-nurture problem, but it is ripe, distinctly, for incisive and well-controlled research.

NEW MEMBERS

Elected November 4, 1940

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Payne, Nellie M., Ph.D., Assistant Research Entomologist, American Cyanamid Co., Stamford, Conn.

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Pease, Robert N., Ph.D., Associate Professor, Chemistry, Princeton University, Princeton, N. J.

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Pinck, Louis A., Ch.E., M.S., Chemist, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

Pollard, E. Fred, Ph.D., Assistant Professor, Chemistry, The Tulane University of Louisiana, New Orleans, La.

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